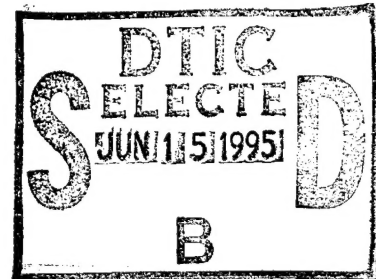




Transmittance Characteristics of U.S. Army Rotary-Wing Aircraft Transparencies

By

**Sean L. Wentworth
Everette McGowin III
Rebecca H. Ivey
Clarence E. Rash
William E. McLean**



Aircrew Health and Performance Division

March 1995

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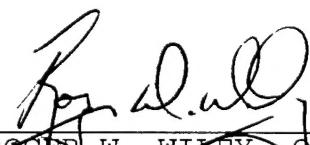
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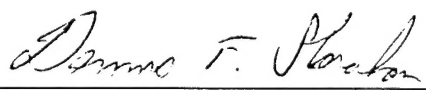
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Director, Aircrew Health and
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Introduction

This report documents a survey of the spectral and luminous transmittance characteristics of transparencies (windscreens) used in currently fielded U.S. Army rotary-wing aircraft (AH-1 Cobra, AH-64 Apache, CH-47 Chinook, OH-6 Cayuse, OH-58A/C/D Kiowa, TH-67 Creek, UH-1 Iroquois, and UH-60 Black Hawk [Figures 1-10]). These characteristics are essential to addressing issues related to aviator and crewman visual performance. In addition, spectral transmittance characteristics impact the performance of helmet-mounted imaging systems, such as the AN/AVS-6 Aviator's Night Vision Imaging System (ANVIS).

Previous investigations of the optical characteristics of U.S. Army rotary-wing aircraft transparencies (Chiou, 1975, 1976; Chiou, Park, and Moser, 1976; Crosley, 1968) may no longer be representative of currently fielded transparencies. Manufacturers of U.S. Army aircraft transparencies often change with each procurement contract. Appendix A provides a list of current manufacturers.

The survey was conducted in two phases. In the first phase, samples of windscreens from each aircraft type were evaluated in the laboratory for photopic (day) and scotopic (night) luminous transmittance. The spectral transmittance of each sample also was measured.

Installed transparencies are exposed continuously to the environment, collision with airborne particulate matter, and the abuses which often accompany aircraft maintenance. Therefore, to provide a more realistic assessment of transmittance values as experienced in the field, a second phase consisting of field measurements of photopic luminous transmittance for windscreens installed on aircraft on the flight line was conducted.

The laboratory measurements were taken on new (or not previously used) transparency samples. Due to limited availability of such transparencies, only a single sample of each forward windscreen could be obtained for each aircraft type. [An exception to this was the inability to obtain any front windscreens of the OH-6 or the right front windscreen for the UH-60.] Therefore, the data reported herein should be considered only representative of transparency performance. Field measurements (photopic transmittance only) were made on six aircraft per type.

Specifications and requirements

MIL-W-81752A(AS), "Military specification: Windshield systems, fixed wing aircraft, general specification for,"



Figure 1. The AH-1 Cobra.



Figure 2. The AH-64 Apache.



Figure 3. The CH-47D Chinook.



Figure 4. The OH-6 Cayuse.

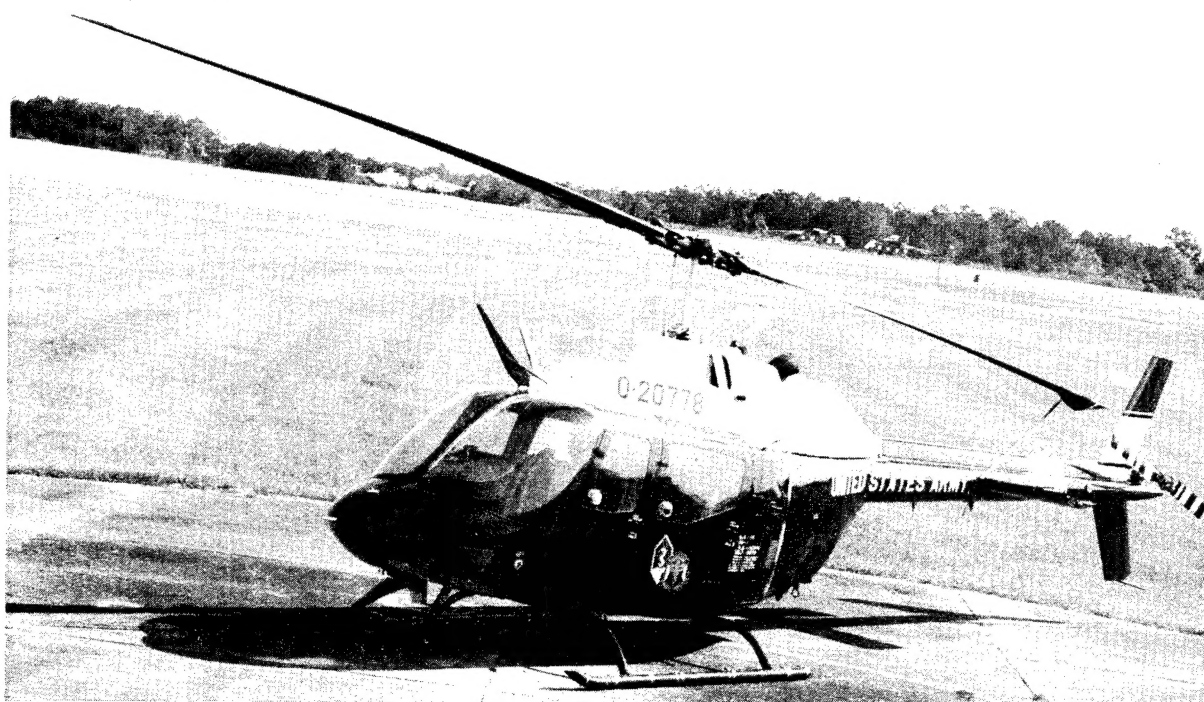


Figure 5. The OH-58A Kiowa.



Figure 6. The OH-58C Kiowa.



Figure 7. The OH-58D Kiowa.

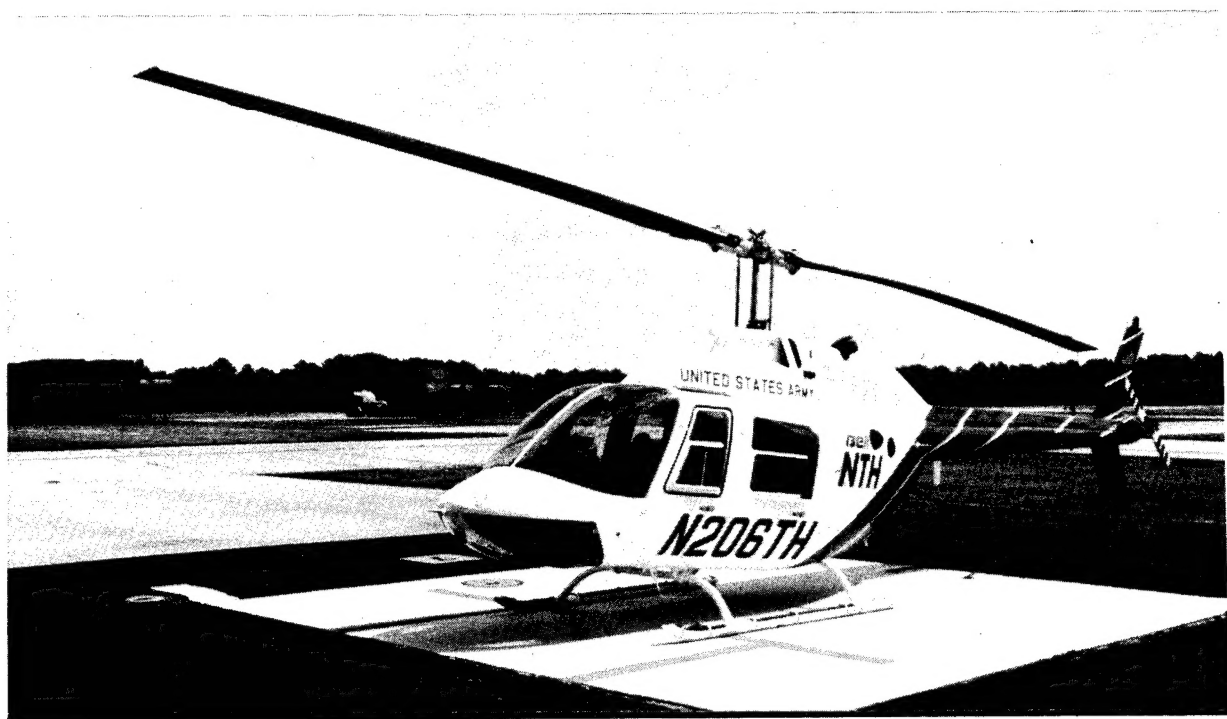


Figure 8. The TH-67 Creek.



Figure 9. The UH-1 Iroquois.



Figure 10. The UH-60 Black Hawk.

requires attack type aircraft to have an average luminous transmittance of not less than 80 percent when measured at normal angles of incidence to the surface. Other aircraft are required to have an average luminous transmittance of not less than 60 percent when measured at normal angles of incidence to the surface.

During day flights, pilotage and other external tasks are primarily accomplished by naked eye viewing through the windscreens and windows. However, current U.S. Army doctrine requires pilots and crewmen to perform missions successfully during periods of low illuminance, e.g., at night and in foul weather. To achieve acceptable performance under these conditions, devices based on the principle of image intensification are used in the cockpit and crew areas. The most prominent of these devices is the ANVIS. This night vision system has a spectral response of 450-950 nanometers (nm) with an enhanced sensitivity from 625-900 nm (MIL-L-85762A). Windscreens and windows must provide adequate spectral transmittance over this latter spectral range to optimize ANVIS performance.

MIL-W-81752A(AS) states the windshield shall be (ANVIS) compatible over the wavelength range of 600-900 nanometers.

Methodology

Spectral transmittance

Spectral transmittance data were obtained in a darkened laboratory using an EG&G Gamma Scientific* model C-9 spectral scanning system and a model RS-1 tungsten source. Spectro-radiometric data were measured over the wavelength range of 350-950 nanometers in 5-nm steps for the reference tungsten source alone and for each transparency sample/source combination. The transmittance curves were obtained by performing a division, by wavelength, of the transparency/source combination data by the source data.

A sample of the left front windscreen was measured in each aircraft with side-by-side seating. A lower front windscreen sample was measured for the attack aircraft, which have tandem seating. In order to minimize scratching of the unused transparencies during measurement, the protective sheeting was removed from as small an area as possible. Therefore, measurements were taken at arbitrary and different points on each samples. [Note: This was not considered to be a relevant factor since an investigation of several samples showed a variation of less than 5 percent across the sample. A similar investigation

*See Appendix B.

of the effect of slant (deviation from normal) also showed a variation of less than 5 percent.] Settings of 900 volts photomultiplier tube anode voltage and 1-degree aperture size on the collection optics were used.

Luminous transmittance

Photopic and scotopic luminous transmittance values were measured in a darkened laboratory using a Photo Research* model 1980A photometer and EG&G Gamma Scientific model RS-1 tungsten source. Following a prescribed warm-up period for the photometer and the reference lamp, luminous transmittance measurements were taken for each sample using the photopic and scotopic filters integral to the photometer. Each measurement consisted of reading the luminance of the reference lamp, placing the respective transparency sample normal to the optical path, and taking a second luminance reading. The transmittance was calculated by dividing the luminance value obtained of the sample/source combination by the value obtained of the source alone. Three readings were obtained for each sample. The mean of these three values was calculated and reported.

Field measurements

Field measurements of photopic transmittance values were acquired for six of each aircraft type on flight lines at U.S. Army airfields at Fort Rucker, Alabama. [Note: An exception was the OH-58C aircraft, where only four aircraft were measured.] Measurements were made using an EG&G Gamma RS-1 tungsten source powered by a field generator and a Minolta* 1-degree aperture luminance meter. Each measurement consisted of reading the luminance of the reference source alone and reading the reference source luminance from a position of the left seat for aircraft with side-by-side seating and from the front seat of aircraft with tandem seating. The transmittance was calculated by dividing the value obtained from the cockpit by the value of the source alone.

Data

Spectral transmittance

The transmittance curves for the windscreen sample are provided in Figures 11-18. The samples from AH-64 (except aft windscreen), CH-47, UH-1, and UH-60 aircraft were of glass composition. The AH-1, OH-58A/C/D, and TH-67 samples were of acrylic composition. All samples were of "clear" material except for the TH-67, which had a bluish tint.

TITLE: AH-1 Cobra
DEVICE: Cobra #0476/
DATE: 07-11-1994
MAX: .93869
MIN: .28553

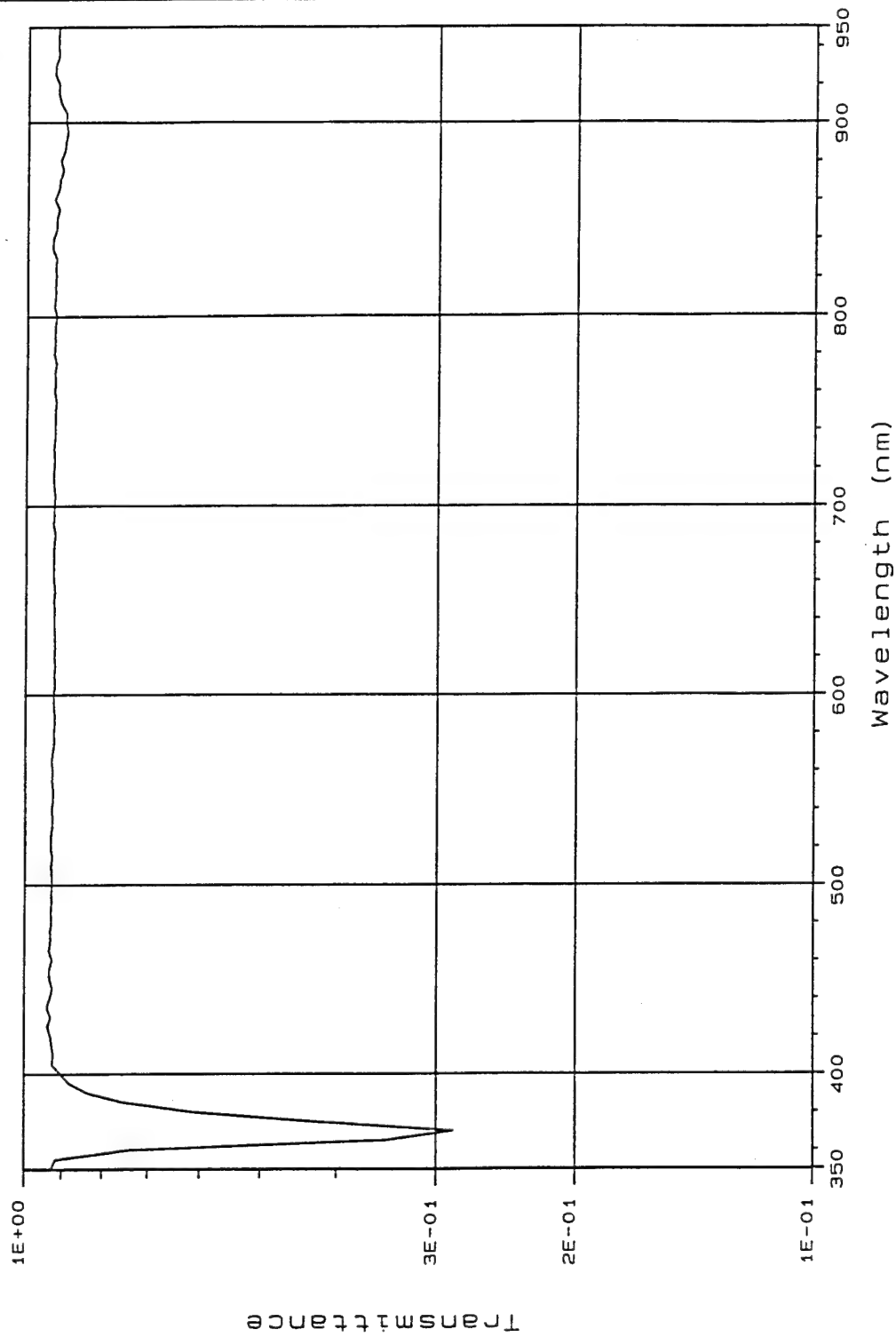


Figure 11. Spectral transmittance curve for AH-1 Cobra.

TITLE: AH-64 Apache
 DEVICE: AH-64 (frwd) #7475/
 DATE: 07-14-1994
 MAX: .84769
 MIN: .62242

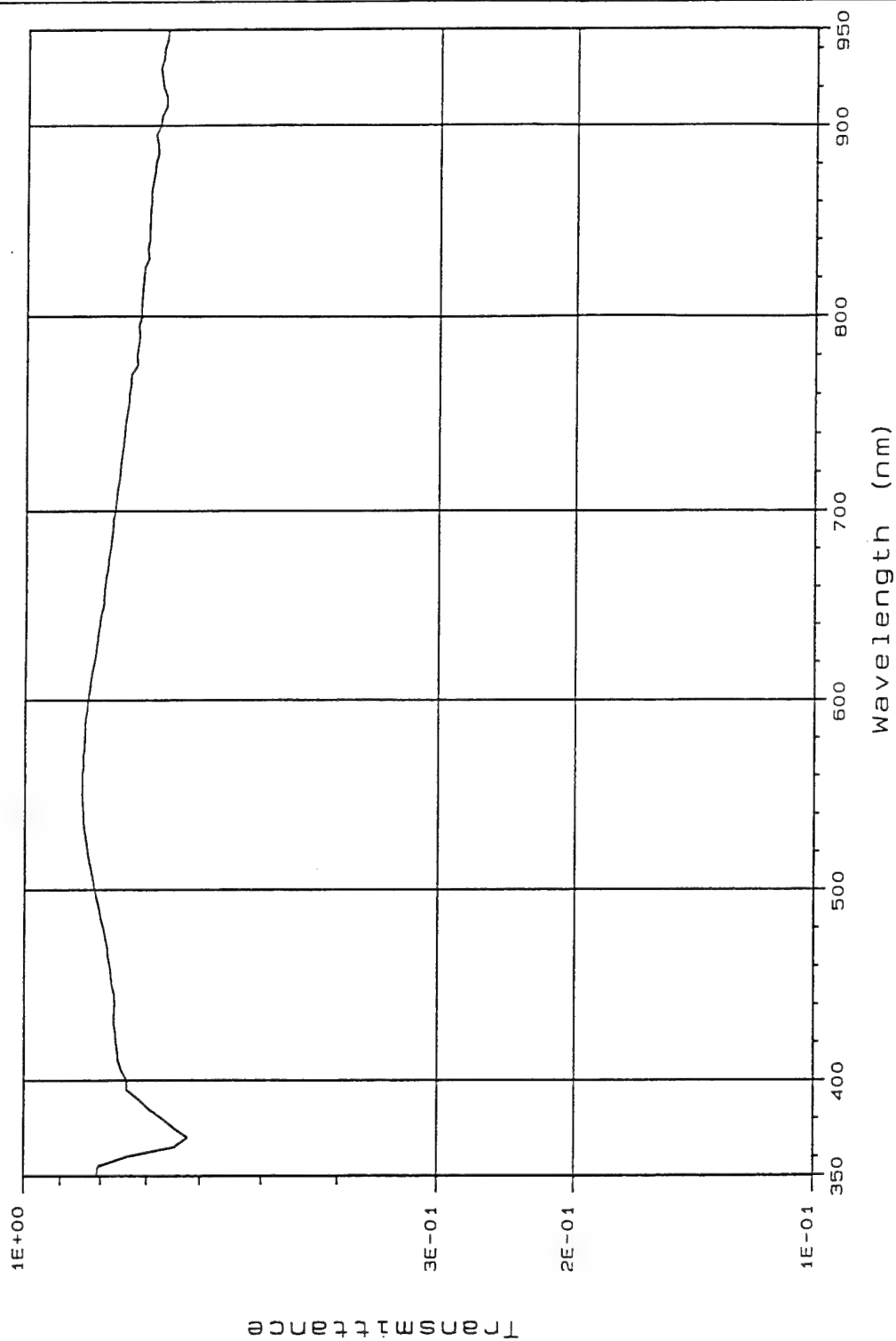


Figure 12. Spectral transmittance curve for AH-64 Apache.

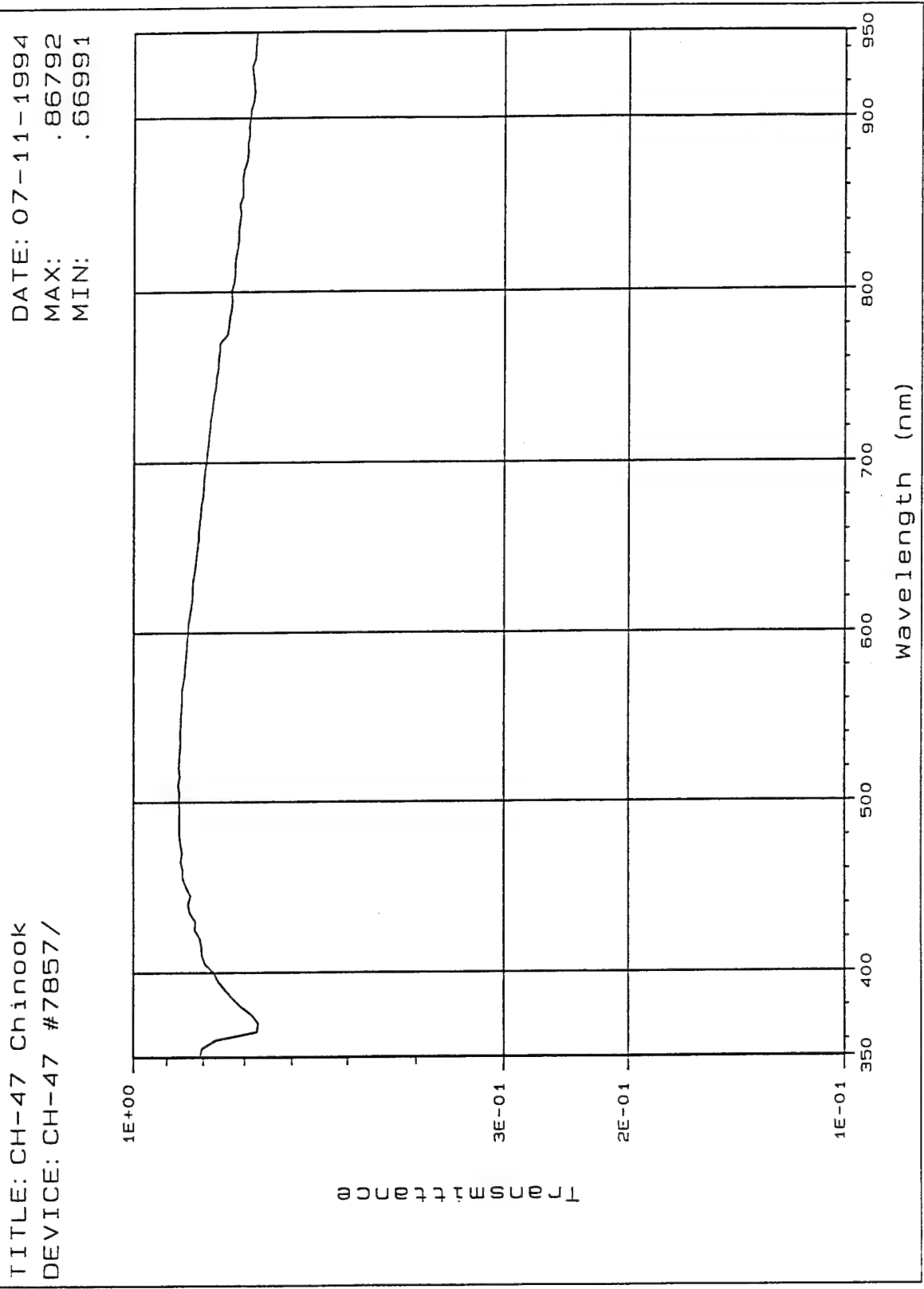


Figure 13. Spectral transmittance curve for CH-47D Chinook.

TITLE: OH-58 ASD Kiowa
DATE: 07-15-1994
DEVICE: OH-58 ASD (18r) #3181/
MAX: .9059
MIN: .4368

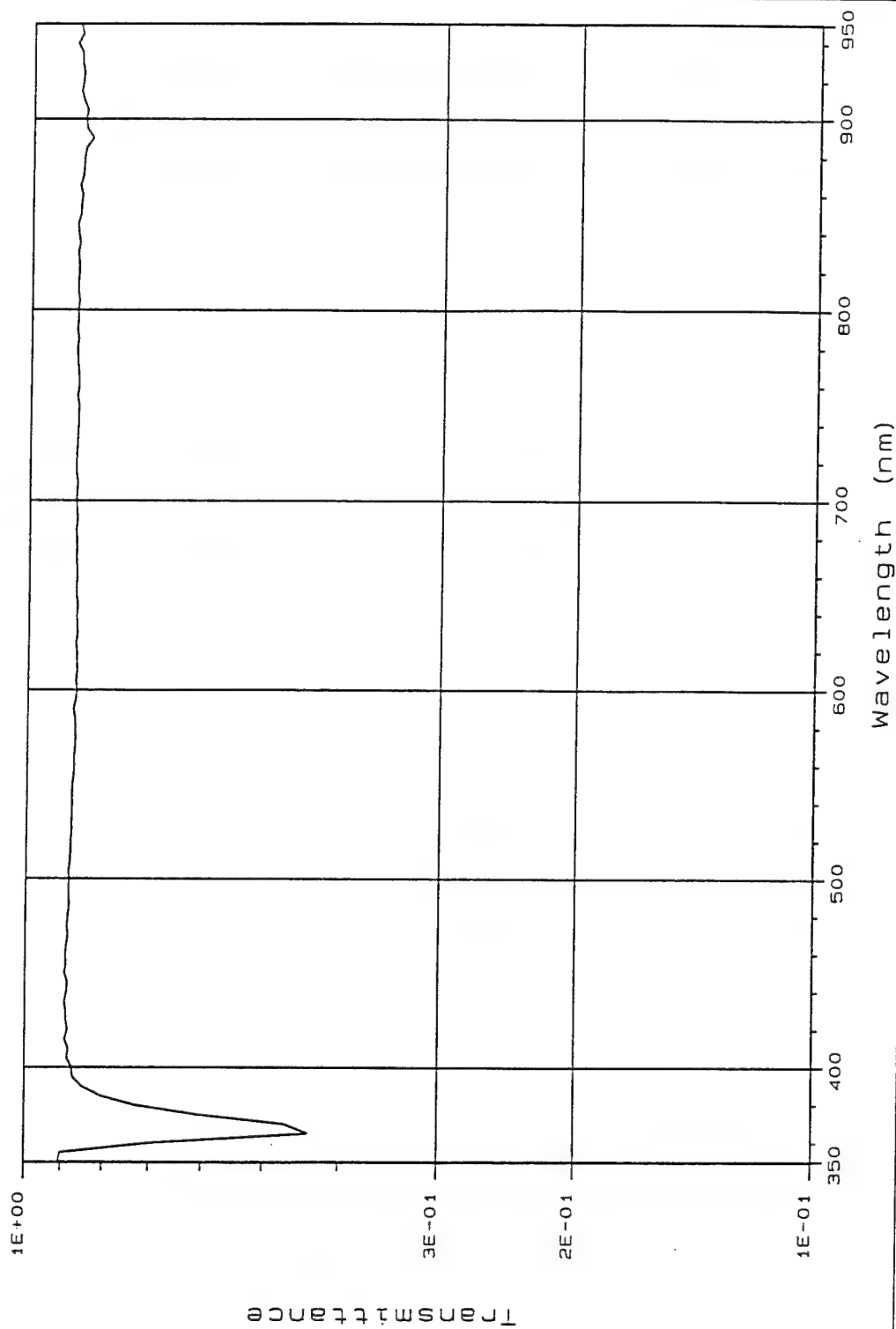


Figure 14. Spectral transmittance curve for OH-58A/D Kiowa.

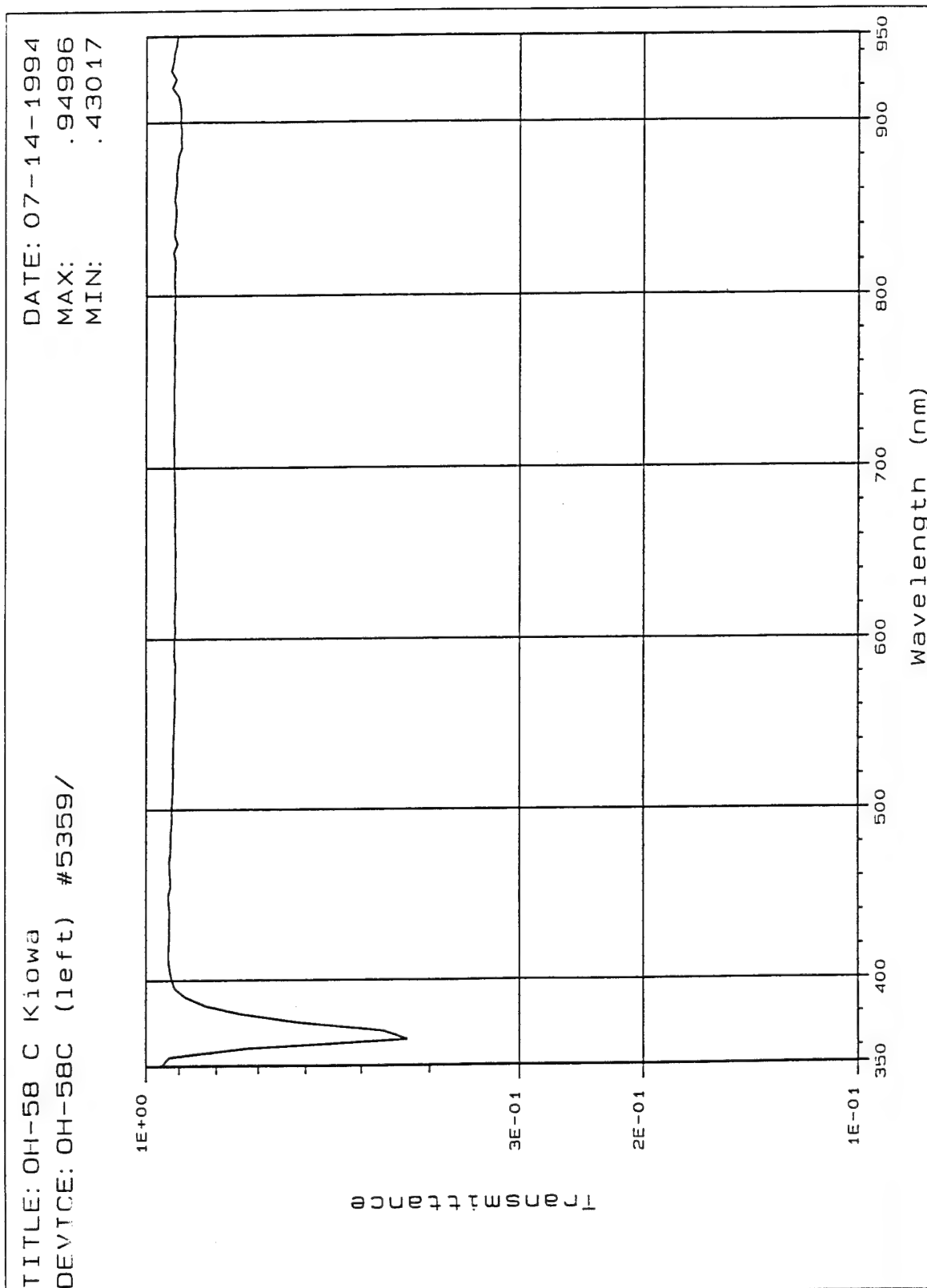


Figure 15. Spectral transmittance curve for OH-58C Kiowa.

TITLE: TH-67 Creek
DEVICE: TH-67 Front Left/
DATE: 08-04-1994
MAX: .92585
MIN: .202

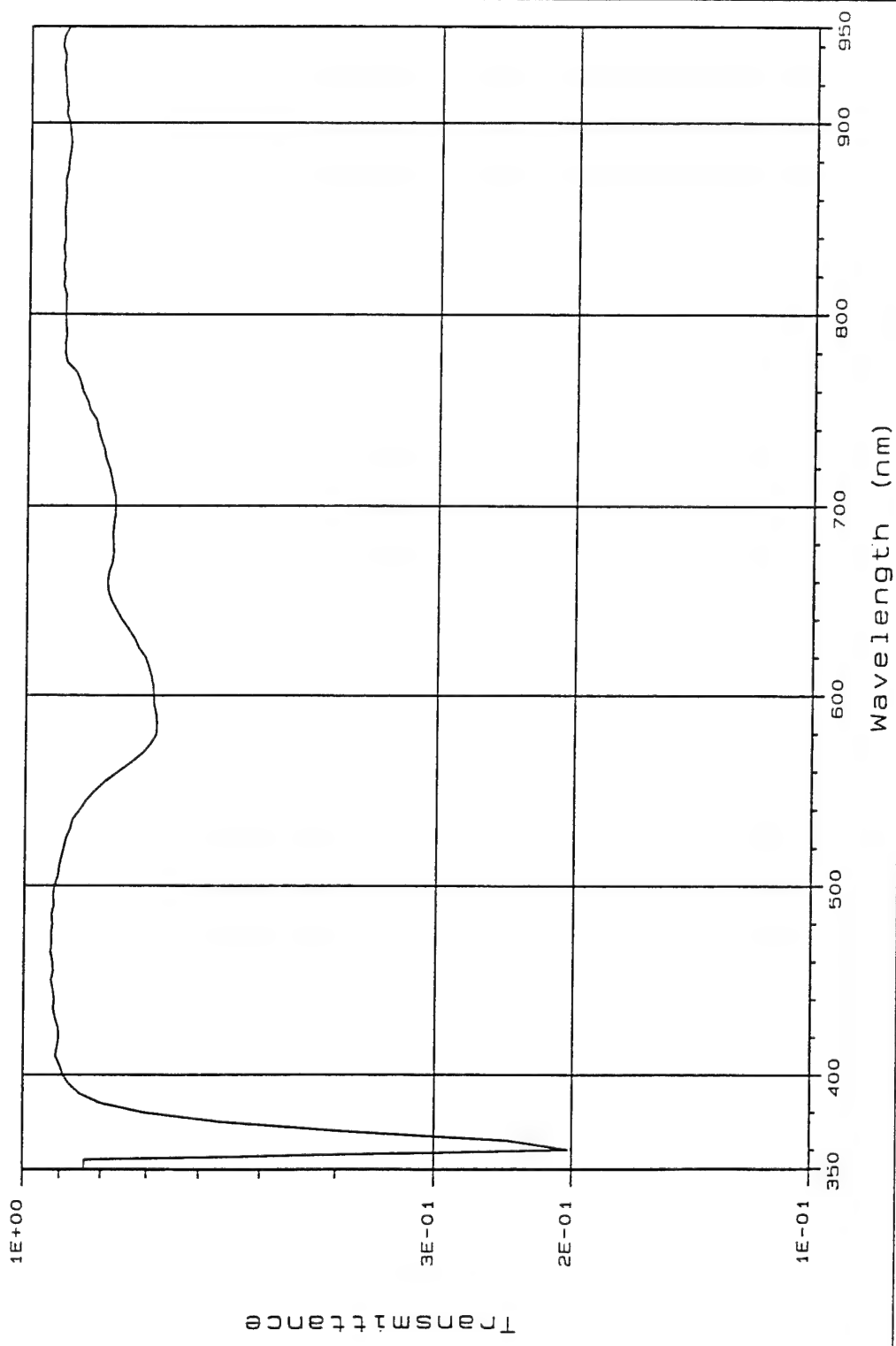


Figure 16. Spectral transmittance curve for TH-67 Creek.

TITLE: UH-1 Iroquois
DEVICE: UH-1 Front Left/
DATE: 08-04-1994
MAX: .88593
MIN: .68467

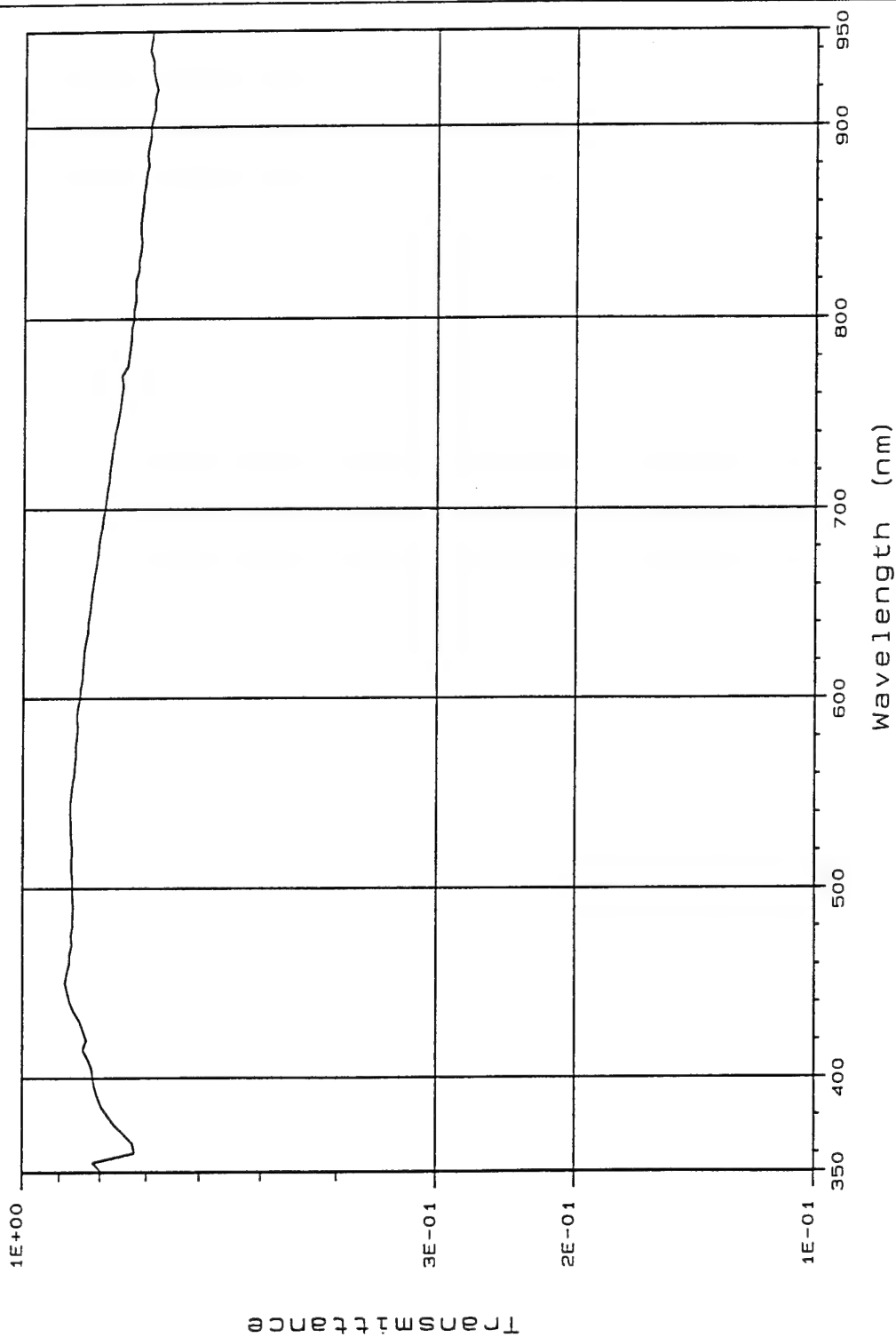


Figure 17. Spectral transmittance curve for UH-1 Iroquois.

TITLE: UH-60 Black Hawk
DATE: 07-13-1994
DEVICE: UH-60 (left) #2249/
MAX: .7692
MIN: .50154

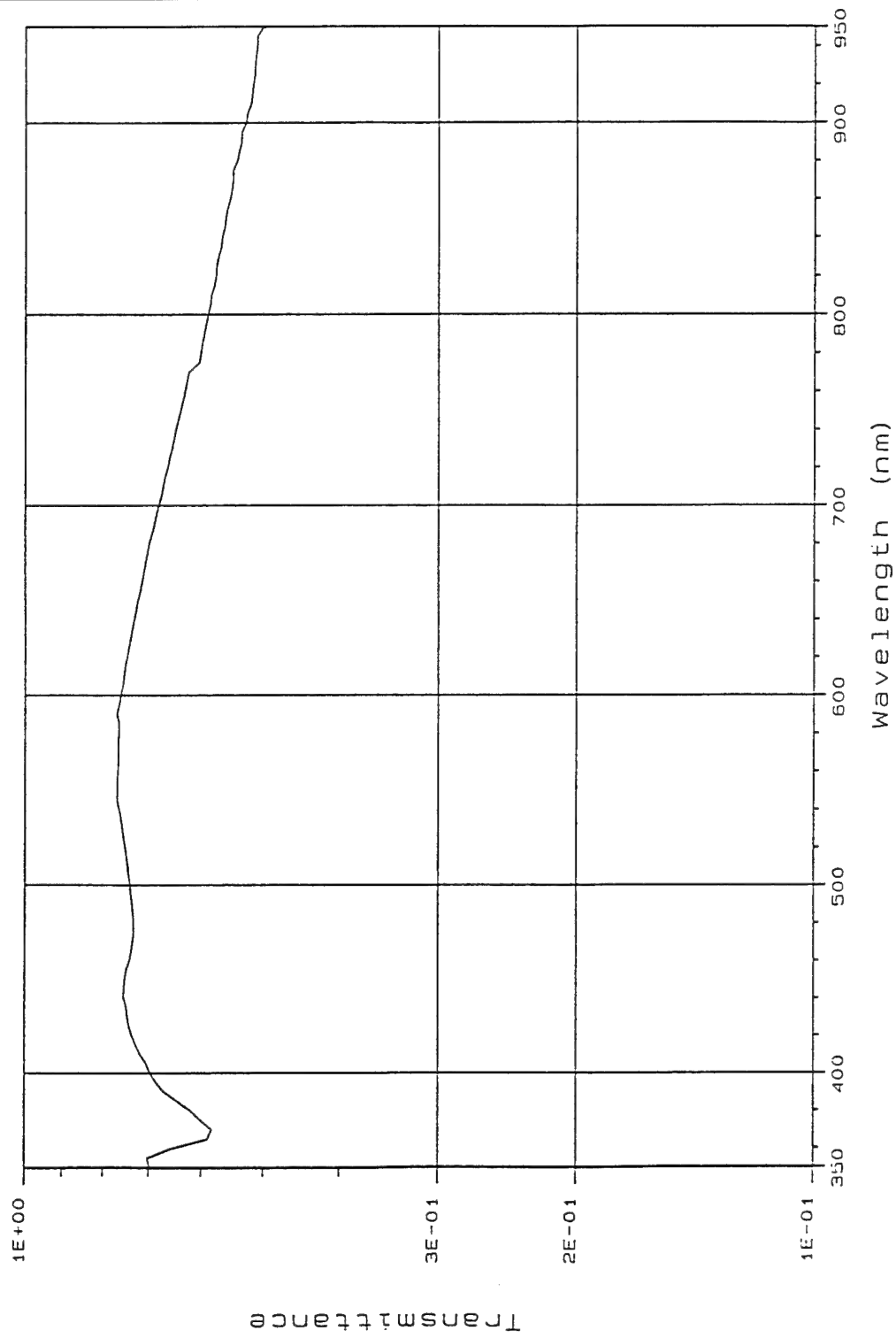


Figure 18. Spectral transmittance curve for UH-60 Black Hawk.

The spectral curves in Figures 11-18 correspond to the descriptions above. The curves for the AH-1, OH-58, and TH-67 samples demonstrate the spectral transmittance characteristics of acrylic materials. These include an ultraviolet cut-off between 350-380 nm and excellent spectral neutrality (flatness of transmittance) over the visible spectral range 400-780 nm. These acrylic windscreens also provide high, relatively flat, transmittance over the spectral response range of the ANVIS, 450-930 nm. The TH-67 sample has a deviation from neutrality over the range 560-780 nm (Figure 16). This decrease in transmittance of the red wavelengths produces the bluish color of the tint.

The glass samples of the AH-64, CH-47, UH-1, and UH-60 also provide a relatively neutral transmittance over the measured spectral range with a similar UV cutoff around 360 nm, but present some relative falloff in transmittance beyond 600 nm. This is of little significance to naked eye vision, which peaks at 550 nm. It also has little effect on ANVIS performance, which has enhanced sensitivity over the spectral range of 625-900 nm.

Note 1: The OH-6, while not available for laboratory measurement of spectral transmittance, is manufactured from acrylic material and should have optical characteristics similar to the AH-1, OH-58A, and TH-67 samples.

Note 2: The apparent increase of transmittance below 360 nm present in the curves is an artifact of the collection optics and spectral sensitivity of the spectroradiometer.

Luminous transmittance

Clear glass materials typically provide 80 to 92 percent photopic luminous transmittance; acrylic typically provides 85 to 92 percent (IES, 1984). The photopic and scotopic luminous values obtained in the laboratory measurements are presented in Table 1. The photopic values ranged from 73 to 93 percent; scotopic values ranged from 81 to 91 percent. When the TH-67 tinted samples are excluded, the photopic values for the glass samples ranged from 82 to 88 percent and the values for the acrylic samples ranged from 90 to 93 percent. The lowest photopic values, 73 and 77 percent, were for the tinted TH-67 samples.

The scotopic values generally tracked within a few percentage points of their corresponding photopic values. This was due to the flatness of the transmittance properties of glass and acrylic. The exception, as noted, of the TH-67 samples and their attenuation of red light produced higher scotopic values.

Based on the laboratory measurements, all of the tested windscreen samples met the requirements of MIL-W-81752A(AS).

The photopic luminous transmittance values obtained for flight line aircraft are presented in Table 2. These values ranged from 58 to 84 percent.

Table 1.

Luminous transmittance (in percent).

Aircraft	Panel position and FSN*	Photopic	Scotopic
AH-1	front 1560-01-028-0476	92	91
AH-64	forward 1560-01-170-7475	82	81
AH-64	center 1560-01-170-7474	82	81
AH-64	aft 1560-01-165-9621	88	89
CH-47	right 1560-00-133-7158	83	82
CH-47	center 1560-00-113-7857	85	87
CH-47	left 1560-00-133-7157	82	82
OH-6	left 1560-00-133-6186	**	**
	right 1560-00-133-6229		
OH-58A	right 1560-00-127-3179	90	91
OH-58A	left 1560-00-127-3181	92	91
OH-58C	right 1560-01-070-5360	92	91
OH-58C (curved)	left 1560-01-070-5359	92	91
OH-58D	right 1560-00-127-3179	90	91
OH-58D	left 1560-00-127-3181	92	91
TH-67	right 206-031-115-105	73	82
TH-67	left 206-031-115-0335	77	85
UH-1	right 1560-00-433-7271	89	89
UH-1	left 1560-00-433-7321	93	89
UH-60	right 1560-01-084-2250	**	**
UH-60	center 1560-01-207-7485	82	82
UH-60	left 1560-01-084-2249	84	81

* Federal stock number; for TH-67, manufacturer part number is given.

** Samples of OH-6 and OH-58 flat windscreens and the right front UH-60 windscreen were not available.

Table 2.

Field measurements of photopic luminous transmittance
(in percent).

Aircraft windscreen	Photopic transmittances (in percent)	Mean	Standard deviation
AH-1 front bottom	83, 75, 76, 81, 77, 82	79	3.4
AH-64 front bottom	71, 67, 76, 72, 73, 70	72	3.0
CH-47 front left	--, 62, 68, 70, 63, 48*	66	3.9
OH-6 front left	80, 70, 67, 70, 71, 75	72	4.6
OH-58A front left	77, 77, 75, 78, 76, 75	76	1.2
OH-58C curved front left	53, 62, 59, 58*	58	3.7
OH-58C flat front left	70, 60, 58, 63, 58, 66	63	4.8
OH-58D front left	71, 72, 73, 74, 70, 76	73	2.2
TH-67 front left	65, 64, 62, 64, 63, 67	64	1.7
UH-1 front left	83, 86, 84, 82, 84, 84	84	1.3
UH-60 front left	5, 75, 75, 71, 74, 75	74	1.6

* Note: For the CH-47, the first reading was invalid due to a recording error and for the last reading, condensation on the interior of windscreen produced an erroneous value; neither value is shown in the table. For the OH-58C with curved windscreen, only four aircraft were available for measurement. These windscreens exhibited significant levels of abrasion and the obtained values were further affected by condensation and fogging.

In Table 3, a comparison between the laboratory and field photopic luminous transmittance values (for front left windscreens) is presented. The percent decrease in photopic transmittance between the unused and fielded windscreens are presented in the last column. In each case, the field value decreased from the laboratory value. Percent decrease

Table 3.

Comparison of laboratory and field photopic luminous transmittance measurements.

Aircraft	Laboratory value	Field value	Percent decrease
AH-1	92	79	14
AH-64	82	72	12
CH-47	83	66	20
OH-6	--	72	--
OH-58A	92	76	17
OH-58C curved	92	58	37
OH-58C flat	--	63	--
OH-58D	92	73	21
TH-67	77	64	17
UH-1	93	84	10
UH-60	84	74	12

Note: Unused samples of OH-6 and OH-58C flat windscreens were not available.

ranged from 10 percent for the UH-1 to 37 percent for the OH-58C (curved). The mean percent decrease was 18 percent. (If the relatively large percent decrease value of 37 for the OH-58C is excluded, the mean percent decrease was 15 percent.) Several factors attributed to this decrease. As would be expected under field conditions, the windscreens were dirty both inside and outside. In addition, because the field measurements were

taken at night, condensation and fogging also were present in varying degrees. These factors, while contributing, are considered secondary to the effects of haze resulting from the highly abraded external surfaces of the windscreens. Figure 19 shows an example of an AH-64 windscreen having a significant level of abrasion.

Summary

All of the windscreen samples (except for the tinted TH-67) were found to be spectrally neutral over the visible spectrum. Likewise, all samples indicated sufficient spectral transmittance over the spectral range required for optimal performance of ANVIS.

For luminous transmittance, all of the unused samples measured in the laboratory met the requirements of MIL-W-81752A(AS). However, an analysis of the field measurements of

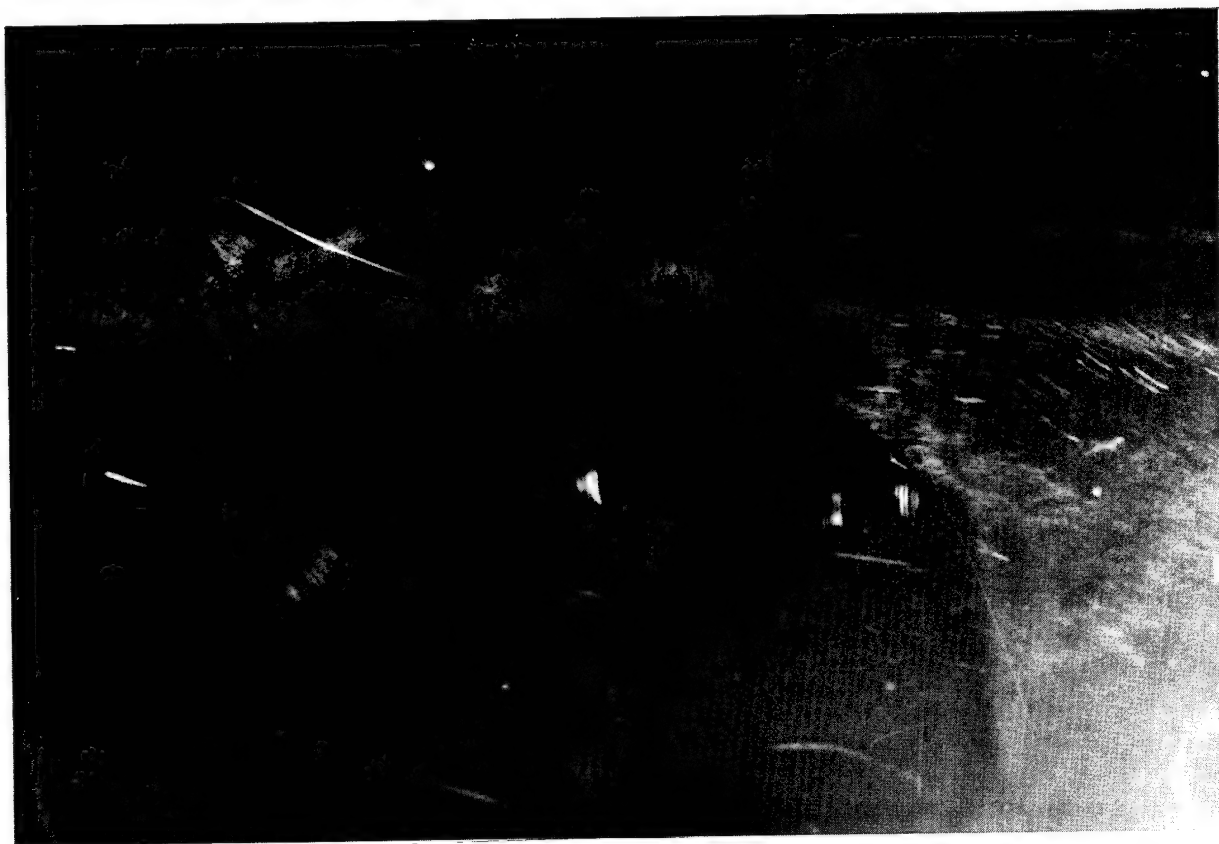


Figure 19. Example of surface abrasion present in an AH-64 windscreen.

luminous transmittance, while qualified by the small sample size, shows significant decreases in transmittance for all windscreen types. These decreases are considered to be caused by haze resulting from the physical abuse to which the windscreens are subjected.

The governing specifications require attack aircraft to have an average luminous transmittance of not less than 80 percent and nonattack aircraft to have not less than 60 percent. All windscreen samples met this requirement in the laboratory measurements. However, based on field measurements, neither attack aircraft, the AH-1 or AH-64, met the 80 percent requirement. The OH-58C curved windscreens, with a mean value of 58 percent, failed to meet the 60 percent requirement for nonattack aircraft. The conclusion which can be drawn from this study seems to be that all windscreen samples meet the specification for luminous transmittance upon delivery, but during usage degrade in performance. Since data were not available to correlate performance degradation with length of service, it is not possible to formulate a recommendation on how often to replace the windscreens. However, it is obvious from the data that in the harsh environments of military flight, the optical performance of the windscreens does degrade below that required by the specification and this situation warrants a policy of closer inspection at the unit level.

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Department of Defense. 1988. Military specification: Windshield systems, fixed wing aircraft, general specification for. Washington, DC: Department of Defense. MIL-W-81752A(AS), Amendment 1.

Illuminating Engineering Society (IES) of North America. 1984. IES lighting handbook. J. E. Kaufman, editor. New York, NY: IES of North America.

Appendix A

List of transparency manufacturers.

AH-1

Bell Helicopter Textron, Inc.
600 E Hurst Blvd.
P.O. Box 482
Fort Worth, TX 76101-8020
(817)280-2011

LP Aero Plastics Inc.
Road 1
P.O. Box B
Jeannette, PA 15644-9730
(412)744-4448

AH-64

McDonald Douglas Helicopter Co.
Sub of McDonald Douglas Corp.
6775 Centinela Ave.
Culver City, CA 90230-6370
(310)305-6562

PPG
Aircraft Product Sales
1719 Highway 72E
P.O. Box 040004
Huntsville, AL 35804
(205)851-7001

CH-47

PPG
Aircraft Product Sales
1719 Highway 72E
P.O. Box 2200
Huntsville, AL 35804
(205)859-2500

Boeing Helicopter
Division of the Boeing Co.
Boeing Center
Industrial Hwy Bldg 3-25
Ridley Park, PA 19078
(215)591-3010

Appendix A (Continued)

List of transparency manufacturers

OH-6

McDonnell Douglas Helicopter Co.
6775 Centinela Ave.
Culver City, CA 90230-6370
(310)305-6562

Ten Cate Aerospace Inc.
5101 Blue Mound Rd.
Fort Worth, TX 76106

Texstar
802 Ave. J East
Grand Prairie, TX 75050-2552
(214)647-1366

OH-58

Bell Helicopter Textron Inc.
600 E Hurst Blvd.
P.O. Box 482
Fort Worth, TX 76101-8020
(817)280-2011

Texstar, Inc.
802 Ave. J East
Grand Prairie, TX 75050-2552
(214)647-1366

TH-67

Bell Helicopter Textron Inc.
600 E Hurst Blvd.
P.O. Box 482
Fort Worth, TX 76101-8020
(817)280-2011

UH-1

PPG Industries, Inc.
Aircraft Product Sales
1719 Highway 72 E
P.O. Box 040004
Huntsville, AL 35804
(205)851-7001

Appendix A (Continued)

List of transparency manufacturers

UH-60

PPG Industries, Inc.
1 PPG PL
Pittsburgh, PA 15272-0001
(412)434-3131

PPG
1719 Highway 72E
P.O. Box 2200
Huntsville, AL 35804
(205)859-8500

Davis Aircraft Product Co. Inc.
1150 Walnut Avenue
P.O. Box 525
Bohemia, NY 11716-2105
(516)563-1500

Appendix B

List of equipment manufacturers

EG&G Gamma Scientific Inc.
3777 Ruffin Rd.
San Diego, CA 92123

Minolta Corporation
101 Williams Drive
Ramsey, NJ 07446

Photo Research
Division of Kollmorgen
9330 DeSoto Ave.
P.O. Box 2192
Chatsworth, CA 91313-2192

Initial distribution

Commander, U.S. Army Natick Research,
Development and Engineering Center
ATTN: SATNC-MIL (Documents
Librarian)
Natick, MA 01760-5040

Chairman
National Transportation Safety Board
800 Independence Avenue, S.W.
Washington, DC 20594

Commander
10th Medical Laboratory
ATTN: Audiologist
APO New York 09180

Naval Air Development Center
Technical Information Division
Technical Support Detachment
Warminster, PA 18974

Commanding Officer, Naval Medical
Research and Development Command
National Naval Medical Center
Bethesda, MD 20814-5044

Deputy Director, Defense Research
and Engineering
ATTN: Military Assistant
for Medical and Life Sciences
Washington, DC 20301-3080

Commander, U.S. Army Research
Institute of Environmental Medicine
Natick, MA 01760

Library
Naval Submarine Medical Research Lab
Box 900, Naval Sub Base
Groton, CT 06349-5900

Executive Director, U.S. Army Human
Research and Engineering Directorate
ATTN: Technical Library
Aberdeen Proving Ground, MD 21005

Commander
Man-Machine Integration System
Code 602
Naval Air Development Center
Warminster, PA 18974

Commander
Naval Air Development Center
ATTN: Code 602-B
Warminster, PA 18974

Commanding Officer
Armstrong Laboratory
Wright-Patterson
Air Force Base, OH 45433-6573

Director
Army Audiology and Speech Center
Walter Reed Army Medical Center
Washington, DC 20307-5001

Commander/Director
U.S. Army Combat Surveillance
and Target Acquisition Lab
ATTN: SFAE-IEW-JS
Fort Monmouth, NJ 07703-5305

Director
Federal Aviation Administration
FAA Technical Center
Atlantic City, NJ 08405

Director
Walter Reed Army Institute of Research
Washington, DC 20307-5100

IAF Liaison Officer for Safety
USAF Safety Agency/SEFF
9750 Avenue G, SE
Kirtland Air Force Base
NM 87117-5671

Naval Aerospace Medical
Institute Library
Building 1953, Code 03L
Pensacola, FL 32508-5600

Command Surgeon
HQ USCENTCOM (CCSG)
U.S. Central Command
MacDill Air Force Base, FL 33608

Director
Directorate of Combat Developments
ATTN: ATZQ-CD
Building 515
Fort Rucker, AL 36362

U.S. Air Force Institute
of Technology (AFIT/LDEE)
Building 640, Area B
Wright-Patterson
Air Force Base, OH 45433

Henry L. Taylor
Director, Institute of Aviation
University of Illinois-Willard Airport
Savoy, IL 61874

Chief, National Guard Bureau
ATTN: NGB-ARS
Arlington Hall Station
111 South George Mason Drive
Arlington, VA 22204-1382

AAMRL/HEX
Wright-Patterson
Air Force Base, OH 45433

Commander
U.S. Army Aviation and Troop Command
ATTN: AMSAT-R-ES
4300 Goodfellow Bouvelard
St. Louis, MO 63120-1798

U.S. Army Aviation and Troop Command
Library and Information Center Branch
ATTN: AMSAV-DIL
4300 Goodfellow Boulevard
St. Louis, MO 63120

Federal Aviation Administration
Civil Aeromedical Institute
Library AAM-400A
P.O. Box 25082
Oklahoma City, OK 73125

Commander
U.S. Army Medical Department
and School
ATTN: Library
Fort Sam Houston, TX 78234

Commander
U.S. Army Institute of Surgical Research
ATTN: SGRD-USM
Fort Sam Houston, TX 78234-6200

Air University Library
(AUL/LSE)
Maxwell Air Force Base, AL 36112

Product Manager
Aviation Life Support Equipment
ATTN: SFAE-AV-LSE
4300 Goodfellow Boulevard
St. Louis, MO 63120-1798

Commander and Director
USAE Waterways Experiment Station
ATTN: CEWES-IM-MI-R,
CD Department
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Commanding Officer
Naval Biodynamics Laboratory
P.O. Box 24907
New Orleans, LA 70189-0407

Assistant Commandant
U.S. Army Field Artillery School
ATTN: Morris Swott Technical Library
Fort Sill, OK 73503-0312

Mr. Peter Seib
Human Engineering Crew Station
Box 266
Westland Helicopters Limited
Yeovil, Somerset BA20 2YB UK

U.S. Army Dugway Proving Ground
Technical Library, Building 5330
Dugway, UT 84022

U.S. Army Yuma Proving Ground
Technical Library
Yuma, AZ 85364

AFFTC Technical Library
6510 TW/TSTL
Edwards Air Force Base,
CA 93523-5000

Commander
Code 3431
Naval Weapons Center
China Lake, CA 93555

Aeromechanics Laboratory
U.S. Army Research and Technical Labs
Ames Research Center, M/S 215-1
Moffett Field, CA 94035

Sixth U.S. Army
ATTN: SMA
Presidio of San Francisco, CA 94129

Commander
U.S. Army Aeromedical Center
Fort Rucker, AL 36362

Strughold Aeromedical Library
Document Service Section
2511 Kennedy Circle
Brooks Air Force Base, TX 78235-5122

Dr. Diane Damos
Department of Human Factors
ISSM, USC
Los Angeles, CA 90089-0021

U.S. Army White Sands
Missile Range
ATTN: STEWS-IM-ST
White Sands Missile Range, NM 88002

Director, Airworthiness Qualification Test
Directorate (ATTC)
ATTN: STEAT-AQ-O-TR (Tech Lib)
75 North Flightline Road
Edwards Air Force Base, CA 93523-6100

Ms. Sandra G. Hart
Ames Research Center
MS 262-3
Moffett Field, CA 94035

Commander
USAMRMC
ATTN: SGRD-UMZ
Fort Detrick, Frederick, MD 21702-5009

Commander
U.S. Army Health Services Command
ATTN: HSOP-SO
Fort Sam Houston, TX 78234-6000

U. S. Army Research Institute
Aviation R&D Activity
ATTN: PERI-IR
Fort Rucker, AL 36362

Commander
U.S. Army Safety Center
Fort Rucker, AL 36362

U.S. Army Aircraft Development
Test Activity
ATTN: STEBG-MP-P
Cairns Army Air Field
Fort Rucker, AL 36362

Commander
USAMRMC
ATTN: SGRD-PLC (COL R. Gifford)
Fort Detrick, Frederick, MD 21702

TRADOC Aviation LO
Unit 21551, Box A-209-A
APO AE 09777

Netherlands Army Liaison Office
Building 602
Fort Rucker, AL 36362

British Army Liaison Office
Building 602
Fort Rucker, AL 36362

Italian Army Liaison Office
Building 602
Fort Rucker, AL 36362

Directorate of Training Development
Building 502
Fort Rucker, AL 36362

Chief
USAHEL/USAAVNC Field Office
P. O. Box 716
Fort Rucker, AL 36362-5349

Commander, U.S. Army Aviation Center
and Fort Rucker
ATTN: ATZQ-CG
Fort Rucker, AL 36362

Dr. Sehchang Hah
Dept. of Behavior Sciences and
Leadership, Building 601, Room 281
U. S. Military Academy
West Point, NY 10996-1784

Canadian Army Liaison Office
Building 602
Fort Rucker, AL 36362

German Army Liaison Office
Building 602
Fort Rucker, AL 36362

French Army Liaison Office
USAAVNC (Building 602)
Fort Rucker, AL 36362-5021

Australian Army Liaison Office
Building 602
Fort Rucker, AL 36362

Dr. Garrison Rapmund
6 Burning Tree Court
Bethesda, MD 20817

Commandant, Royal Air Force
Institute of Aviation Medicine
Farnborough, Hampshire GU14 6SZ UK

Defense Technical Information
Cameron Station, Building 5
Alexandra, VA 22304-6145

Commander, U.S. Army Foreign Science
and Technology Center
AIFRTA (Davis)
220 7th Street, NE
Charlottesville, VA 22901-5396

Commander
Applied Technology Laboratory
USARTL-ATCOM
ATTN: Library, Building 401
Fort Eustis, VA 23604

Commander, U.S. Air Force
Development Test Center
101 West D Avenue, Suite 117
Eglin Air Force Base, FL 32542-5495

Aviation Medicine Clinic
TMC #22, SAAF
Fort Bragg, NC 28305

Dr. H. Dix Christensen
Bio-Medical Science Building, Room 753
Post Office Box 26901
Oklahoma City, OK 73190

Commander, U.S. Army Missile
Command
Redstone Scientific Information Center
ATTN: AMSMI-RD-CS-R
/ILL Documents
Redstone Arsenal, AL 35898

Aerospace Medicine Team
HQ ACC/SGST3
162 Dodd Boulevard, Suite 100
Langley Air Force Base,
VA 23665-1995

U.S. Army Research and Technology
Laboratories (AVSCOM)
Propulsion Laboratory MS 302-2
NASA Lewis Research Center
Cleveland, OH 44135

Commander
USAMRMC
ATTN: SGRD-ZC (COL John F. Glenn)
Fort Detrick, Frederick, MD 21702-5012

Dr. Eugene S. Channing
166 Baughman's Lane
Frederick, MD 21702-4083

U.S. Army Medical Department
and School
USAMRDALC Liaison
ATTN: HSMC-FR
Fort Sam Houston, TX 78234

NVESD
AMSEL-RD-NV-ASID-PST
(Attn: Trang Bui)
10221 Burbeck Road
Fort Belvoir, VA 22060-5806

CA Av Med
HQ DAAC
Middle Wallop
Stockbridge, Hants S020 8DY UK

Dr. Christine Schlichting
Behavioral Sciences Department
Box 900, NAVUBASE NLON
Groton, CT 06349-5900

Commander
Aviation Applied Technology Directorate
ATTN: AMSAT-R-TV
Fort Eustis, VA 23604-5577

COL Yehezkel G. Caine, MD
Surgeon General, Israel Air Force
Aeromedical Center Library
P. O. Box 02166 I.D.F.
Israel

HQ ACC/DOHP
205 Dodd Boulevard, Suite 101
Langley Air Force Base,
VA 23665-2789

41st Rescue Squadron
41st RQS/SG
940 Range Road
Patrick Air Force Base,
FL 32925-5001

48th Rescue Squadron
48th RQS/SG
801 Dezonias Road
Holloman Air Force Base,
NM 88330-7715

HQ, AFOMA
ATTN: SGPA (Aerospace Medicine)
Bolling Air Force Base,
Washington, DC 20332-6128

ARNG Readiness Center
ATTN: NGB-AVN-OP
Arlington Hall Station
111 South George Mason Drive
Arlington, VA 22204-1382

35th Fighter Wing
35th FW/SG
PSC 1013
APO AE 09725-2055

66th Rescue Squadron
66th RQS/SG
4345 Tyndall Avenue
Nellis Air Force Base, NV 89191-6076

71st Rescue Squadron
71st RQS/SG
1139 Redstone Road
Patrick Air Force Base,
FL 32925-5000

Director
Aviation Research, Development
and Engineering Center
ATTN: AMSAT-R-Z
4300 Goodfellow Boulevard
St. Louis, MO 63120-1798

Commander
USAMRMC
ATTN: SGRD-ZB (COL C. Fred Tyner)
Fort Detrick, Frederick, MD 21702-5012

Commandant
U.S. Army Command and General Staff
College
ATTN: ATZL-SWS-L
Fort Leavenworth, KS 66027-6900

ARNG Readiness Center
ATTN: NGB-AVN-OP
Arlington Hall Station
111 South George Mason Drive
Arlington, VA 22204-1382

Director
Army Personnel Research Establishment
Farnborough, Hants GU14 6SZ UK

Dr. A. Kornfield
895 Head Street
San Francisco, CA 94132-2813

ARNG Readiness Center
ATTN: NGB-AVN-OP
Arlington Hall Station
111 South George Mason Drive
Arlington, VA 22204-1382

Commander, U.S. Army Test
and Evaluation Command
Directorate for Test and Evaluation
ATTN: AMSTE-TA-M (Human Factors
Group)
Aberdeen Proving Ground,
MD 21005-5055

Naval Air Systems Command
Technical Air Library 950D
Room 278, Jefferson Plaza II
Department of the Navy
Washington, DC 20361

Director
U.S. Army Ballistic
Research Laboratory
ATTN: DRXBR-OD-ST Tech Reports
Aberdeen Proving Ground, MD 21005

Commander
U.S. Army Medical Research
Institute of Chemical Defense
ATTN: SGRD-UV-AO
Aberdeen Proving Ground,
MD 21010-5425

Commander
USAMRMC
ATTN: SGRD-RMS
Fort Detrick, Frederick, MD 21702-5012

HQ DA (DASG-PSP-O)
5109 Leesburg Pike
Falls Church, VA 22041-3258

Harry Diamond Laboratories
ATTN: Technical Information Branch
2800 Powder Mill Road
Adelphi, MD 20783-1197

U.S. Army Materiel Systems
Analysis Agency
ATTN: AMXSY-PA (Reports Processing)
Aberdeen Proving Ground
MD 21005-5071

U.S. Army Ordnance Center
and School Library
Simpson Hall, Building 3071
Aberdeen Proving Ground, MD 21005

U.S. Army Environmental
Hygiene Agency
ATTN: HSHB-MO-A
Aberdeen Proving Ground, MD 21010

Technical Library Chemical Research
and Development Center
Aberdeen Proving Ground, MD
21010-5423

Commander
U.S. Army Medical Research
Institute of Infectious Disease
ATTN: SGRD-UIZ-C
Fort Detrick, Frederick, MD 21702

Director, Biological
Sciences Division
Office of Naval Research
600 North Quincy Street
Arlington, VA 22217

Commandant
U.S. Army Aviation
Logistics School ATTN: ATSQ-TDN
Fort Eustis, VA 23604

Headquarters (ATMD)
U.S. Army Training
and Doctrine Command
ATTN: ATBO-M
Fort Monroe, VA 23651

Cdr, PERSCOM
ATTN: TAPC-PLA
200 Stovall Street, Rm 3N25
Alexandria, VA 22332-0413

HQ, AFOMA
ATTN; SGPA (Aerospace Medicine)
Bolling Air Force Base,
Washington, DC 20332-6188